SECTION 3
PRODUCTS OF THE STUDY

General

The primary FKCCS product will be a carrying capacity analysis for the Florida Keys. It will be performed by applying future scenarios to a spatially explicit carrying capacity analysis model (CCAM) that utilizes land development impacts as a common denominator. The scenarios reflect different visions of the Florida Keys, and will be applied to the CCAM to allow for comparable output. The output provided will consist of an evaluation, by element, of the projected impact of each scenario and Geographic Information System (GIS) maps that graphically display the impact. Beyond revealing presently exceeded natural resource and species of concern tolerance limits, this approach is intended to define the impact(s) of a scenario prior to any crisis stage or degradation.

Other products of this study will include a set of "tools" to support future studies and analyze other future scenarios. The set of tools will include: element databases and relationships; the CCAM; and a GIS database. These tools may also be used to evaluate the sensitivities of input assumptions and tolerance limits and will continue to serve as a basis for future planning efforts in response to new information and/or changes in element relationships.

Central to this analysis is the identification and development of each study element (described in more detail in Section 4). This will be accomplished through the development of scientifically derived carrying capacity tolerance limits and identification of the explicit linkage of the element to population as a measure of land development activities. The complexity of carrying capacity tolerance limits, linkages and interrelationships will be addressed through incorporating risk and uncertainty analyses in the CCAM (IWR 1996).

Scenario Development

Five separate scenarios shall be developed and evaluated according to the descriptions herein. Four of the scenarios represent different future conditions and one scenario represents the pre-1930's (pre-overland highway) condition of the Keys. Where applicable, the evaluation of the impacts of widening U.S. Highway 1 will also be simulated for a scenario. Each scenario shall include tolerance limit input for all study elements. Expression of the tolerance limit information (measurement units) may vary from element to element. For example, species tolerance limits are typically described as the upper limit of a given range of tolerance prior to the occurrence of negative impacts to the species population. Similarly, the tolerance limit equivalent for an infrastructure element is often described as the upper limit of service that can be provided prior to incurring additional costs of retrofitting or new construction. Each tolerance limit will be linked to population, as a measure of land development activities, and its distribution

through time and space. This will be the cornerstone assumption upon which the impact of the scenarios will be determined.

The complete development of each scenario is a critical step in the carrying capacity analysis. Regarding the carrying capacity methodology, the following will be determined for each scenario:

Task 1. Spatial partitioning (i.e. how the elements for the scenario will be partitioned across space). What is the smallest area (minimum mapping unit) that will be looked at? Will it be a parcel, block, acre, key or group of keys? Some elements are likely to be very detailed while others may be coarse;

Task 2. Temporal partitioning (i.e. scenario time period and time step). How long of a period will be considered and how many time steps will be in that period? Are results going to tabulated every 1 year or every 5 years for 20 years? Unlike spatial partitioning, the time period and time step should be the same for all elements in a given scenario;

Task 3. Population distribution (spatial and temporal). How is the effective human population distributed in space and time? Effective population is defined as the number of all users (permanent, seasonal, tourist) residing in the study area at any given point in time. Effective population in this case must consider the various resource consumption patterns of tourists versus seasonal residents versus permanent residents. Therefore, population distribution will include differentiation of population breakdown (i.e. permanent, seasonal and tourist) and determination of appropriate factor(s) for application to the projected population forecast to account for the various resource consumption patterns; and

Task 4. Input assumptions:

Scenario 1. Historical Condition. Using available data, this scenario shall define natural resource conditions in the Florida Keys prior to construction of the overland highway. Information on the natural resources of the Keys prior to extensive land development activities will be developed. This information will be used for comparison purposes, wherever possible, with present day conditions of natural resources. Since it is likely that sufficient and suitable data may not be available, this scenario may not be input into CCAM, however, all historical data will be mapped and archived.

Scenario 2 Current Amount of Developed Land with Preservation Aspect. This scenario shall define a snapshot of the existing condition in the Keys. Future conditions will require natural resource preservation, with no net increase in the amount of developed land. Redevelopment and restoration opportunities will be identified and implemented. Preservation of vacant land will be required unless a restoration trade-off can be performed (e.g. development of vacant land in a non-critical habitat area (less environmentally sensitive) in exchange for restoration of critical habitat (more environmentally sensitive) including removal of structure(s) in that area). Cost estimates

for restoration opportunities will be provided. The restoration opportunities and cost estimates will be indexed to allow for increasing tourism demand and inflation.

Scenario 3 Optimal Sustainable Future. This scenario will begin with the existing condition in the Keys and future conditions will represent sustainable development in the Keys. Critical upland/wetland sites will be selected for natural resource conservation and restoration. Site selection will consider maintenance of ecosystem processes through adequate habitat representation with minimal disturbance. Corridors between selected sites and existing protected areas will be maintained. Sustainable development methodology, such as clustered developments, will be utilized on sites deemed non-critical upland or wetland sites. As with all of the other scenarios, a full representation of elements will be displayed, however, this scenario will maintain an optimum sustainable level (i.e. most beneficial) for each element. This scenario will compare elements, identifying conflicts and those elements that, if allowed to dominate, may have the potential to inhibit sustainability in the Florida Keys.

Scenario 4 Current Rate of Growth to Build Out. This scenario shall reflect total build out in the Florida Keys. All vacant lands consistent with land development regulations, building codes and schedules shall be projected as developed in accordance with Monroe County's Comprehensive Plan. The build out projections for land development activities are available from Monroe County Growth Management Office.

Scenario 5. Catastrophic Event. This scenario will separately simulate a category 5 hurricane impact on each of the three individual zones defined in Monroe County's Hurricane Evacuation Plan. Damages to public and private infrastructure and natural resources will be simulated. This scenario shall address, within the context of each element, (1) the cost of reconstruction, in the case of infrastructure or the cost of restoration, in the case of natural habitat and (2) the cost to purchase the impacted land in lieu of reconstruction or restoration. This catastrophic event shall be applied to scenarios 2, 3 and 4, at the point in time when its fiscal investment has been maximized.

Study Elements

Study elements identified as integral to the sustainability of the Florida Keys are grouped into three categories: Natural Resources; Human Infrastructure; and Social Environment. A quick reference list of these elements is located in the Table of Contents. An individual discussion for each study element is found in Section 4. Databases for each element shall be developed adhering to the following requirements:

1. Databases include, but are not limited to, a documented literature search; data collection from existing sources and studies; and new data collection identified as needed and appropriate.

2. Data collection and database development will be coordinated with and include the requirements of the analysis model.

3. Each database shall define scientifically derived requirements, responses, and limiting factors for each key natural resource indicator or species of concern, identifying and quantifying tolerance limits, where possible, in accordance to the analysis model requirements. This data shall be extrapolated from existing information and/or result from a consensus of a team of experts in each element's appropriate field.

4. Each element database shall identify, where appropriate, areas requiring restoration efforts to ensure ecosystem integrity and/or additional infrastructure investment necessary to support sustainability.

5. Complete citations shall be required to substantiate sound scientific fact. All maps used in the study shall meet National Map Accuracy Standards. All GIS data shall meet the Florida Geographic Information Board (FGIB), Florida Marine Research Institute (FMRI), and the Federal Geographic Data Committee (FGDC) standards.

General deliverables applicable to all elements are listed in the following paragraphs. Specific deliverables, applicable to a specific element, are described in a task list found within each element discussion in Section 4. Although all the elements mentioned in this scope of work shall be included in the study, the study is not strictly limited to this listing. It is possible, through either the public involvement process or element development, an unlisted element may be identified for inclusion in this study.

Task 1. Gather pertinent information on study elements and their requirements, responses, limiting factors and tolerance limits.

Task 2. Define scientifically-derived requirements, responses, and limiting factors for each element, identifying and quantifying tolerance limits, where possible. The requirements, responses, limiting factors and tolerance limits of the natural resources are the criteria upon which the determination of the carrying capacity of the Florida Keys ecosystem will be based. This data will be developed through a series of facilitated workshops immediately following study initiation. Workshop participants will include members of the peer review group that reviewed the SOW in March 1998; other identified natural resource experts; and local, state and federal agency representatives, as appropriate. It is anticipated that two to three workshops will be required:

Workshop Number 1. The first workshop will be held approximately one month following study initiation. The workshop will further define these issues, provide direction for additional research, and identify components of these issues that cannot be resolved within the study period. In the case of the latter, alternatives for proceeding without the requirements, responses, limiting factors, and tolerance limit for the natural resource will be developed.

Workshop Number 2. The second workshop will be held approximately one month following workshop number 1. The purpose of this workshop will be to

present and discuss the proposed requirements, responses, limiting factors and tolerance limit each natural resource, based upon results of the additional research directed by workshop 1. In addition, this workshop will provide further refinement of alternatives to address those issue components that may have been identified at workshop 1 as not resolvable during the study period. The goal of workshop 2 will be to obtain consensus on natural resource requirements, responses, limiting factors and tolerance limits; however, a third workshop will be held if additional research or coordination is required.

Task 3. Develop database. Data collection and database development will be coordinated with and include the requirements of the analysis model.

Task 4. Add any additional study elements and databases as appropriate.

Task 5. Develop a relationship between each study element, land development activities and population changes. The purpose of the relationship is to predict changes in the study element as land development activities occur and the population changes, providing the link between land development activities, effective human population and the natural environment in the Florida Keys. These relationships will be developed through a series of facilitated workshops that will be held immediately following study initiation. It is anticipated that two to three workshops will be required:

Workshop Number 1. This workshop will be held approximately one month after study initiation. Workshop participants will include members of the peer review group that reviewed the SOW in March 1998; other identified demographers and natural resource experts; those with knowledge of past changes in the keys; and local, state and federal agency representatives, as appropriate. The first workshop will further define this issue, provide a brainstorming platform for developing methodologies (i.e. designing studies and scopes of work) for use in defining these relationships and provide direction for additional research. It is possible that this workshop may identify components of the human cause/natural resource effect relationship that cannot be developed within the study period. In this case, alternatives for proceeding without a certain human cause/natural resource effect relationship will be developed.

Workshop Number 2. The second workshop will be held approximately one month following workshop number 1. The purpose of this workshop will be to present and discuss possible methodologies for use in defining the human cause/natural resource effect relationship in the Florida Keys, based upon further research and results of workshop number 1. In addition, this workshop will provide further refinement of alternatives to address proceeding without a certain human cause/natural resource effect relationship. The goal of workshop 2 will be to obtain consensus on the cause/effect relationship methodologies, however, if necessary, a third workshop will be held.

Geographic Information System

Much of the data for this study will fall into two broad categories, graphical data and tabular data. GIS has the capability to manage and query a variety of graphical and tabular information data sets. One notable feature of GIS is that all data are geo-referenced. There are significant amounts of existing data on the Florida Keys available in GIS format with the U.S. Army Corps of Engineers, National Park Service, FMRI, South Florida Water Management District, Florida Keys National Marine Sanctuary, and Monroe County.

The large quantity of data and information that will be collected and compiled as part of this study will require a system for its storage, retrieval, and analysis. All GIS coverages will be turned over to the FMRI for stewardship upon completion of the FKCCS. Therefore, the database design must be closely coordinated with FMRI to ensure compatibility with their standards and practices. Coordination is also required with the FGIB and the FGDC to ensure compatibility with state and federal standards and practices, respectively.

Task 1. Database Design. A design phase is critical to ensure standards are established for the data collection and so that data are organized in a manner to facilitate a variety of future uses. It is anticipated that much of the design work and data definition can be modified from existing documents and databases from several of the above mentioned government agencies. All database design work must be coordinated with FMRI, FGIB and FGDC to ensure compatibility with their GIS standards and practices. In addition, database development will be coordinated with and include the requirements of the analysis model.

Task 1.a. Establish global parameters such as map projection coordinate system and horizontal and vertical datums.

Task 1.b. Compile a list of existing data, data that will be collected as part of the study and the complete set of attributes in the relational database.

Task 1.c. Define minimum accuracy standards for all data types and develop a plan on how to integrate and handle coarse resolution or historic data that cannot meet these requirements but still add value to the study.

Task 1.d. Develop a plan to integrate data sets that are not comprehensive or complete over the whole study area but have a significant use for part of the study area.

Task 1.e. Determine if data size requirements require a tiling of large data sets. If data sets are to be tiled, the GIS must provide a way to access this information as a single data set, or single data sets such as image catalogs or map libraries.

Task 1.f. Provide input and coordination during the concurrent scenario development phase.

Task 1.g. Document completed database design including name and type of data, location of data in the directory structure of each data set, and attribute definitions. The database design must be closely coordinated with FMRI to ensure compatibility with their standards and practices. Coordination is also required with the FGIB and the FGDC to ensure compatibility with state and federal standards and practices, respectively.

Task 2. Purchase Hardware and Software. ARC/INFO and ARCVIEW are the GIS software to be utilized for the KCCS. ARC/INFO is used by the U.S. Army Corps of Engineers, the Florida Marine Research Institute (FMRI) and Monroe County. The FMRI will serve as the repository for all GIS data and coverages developed for this study. Database integration software compatible with ARC/INFO and ARCVIEW (e.g. Oracle) may also be utilized. Hardware requirements will include a multi-tasking workstation capable of handling large images and data sets (exceeding 500 megabytes per file). Due to constantly improving technology, specific hardware recommendations will be developed at the time of acquisition.

Task 3. Database Setup, Initial Data Conversion and Integration. The initial setup of the system and population of the databases from existing data are expected to take several months. Transferring data from other agencies and reformatting it to the specifications developed in the database design phase will be a labor intensive period. It is assumed here that much of the data will arrive in digital format, however, there is likely to be a considerable amount of non-digital data such as paper maps and reports, which must be digitized or will require data input. As information is placed in the GIS, appropriate metadata and accompanying documentation will be created.

Task 4. GIS Database Administration and Use. Information collected, whether new or historical, will require timely placement in the database. Most new data collected according to specifications from the database design should fit in the database with little trouble. Some historical data, however, will require a more labor intensive effort to be entered into the database. Administrative tasks, such as routine backups; data exchange with other agencies, work groups, or contractors; documentation upkeep; and occasional map production or demonstrations, require a database administrator over the life of the study.

Task 5. Documentation. The complete database will be fully documented with a users guide, data dictionaries and metadata submissions. Development of all metadata will be coordinated with FMRI, FGIB and FGDC to ensure state and federal standards are met. Metadata will reside on the FGIB spatial digital library system and on the USACE node of the National Spatial Data Infrastructure (NSDI). All documentation will be available in soft copy form, through the standardized help interface system, as part of the database. Complete documentation will also be provided in hard copy format.

Carrying Capacity Analysis Model

An interactive, spatially explicit, computer-driven carrying capacity analysis model (CCAM) will be developed that interfaces the GIS coverages; input scenarios; element databases that include requirements, responses, limiting factors, and identification and quantification of tolerance limits, where possible; and relationships that describe human and land development impacts on the environment. The CCAM will be a future-oriented, planning and decision-making tool. Risk and uncertainty analyses will be incorporated into the model to improve the planning process and the quality of decisions made to balance the management of environmental resources, human infrastructure and land development activities in the Florida Keys ecosystem. Development of the CCAM will be coordinated with data collection and database design to ensure that all requirements of the analysis model are included.

The analysis model will characterize the differences between the various input scenario assumptions. Then, depending on the scenario, it will simulate the conditions of land development activities and population growth, through time, described by those assumptions. Utilizing the relationships that will describe land development and population growth impacts on the environment, CCAM will determine and inventory the impacts on the natural resources and human infrastructure in the Florida Keys. Next, CCAM will compare the impacts on the natural resource elements with their associated requirements, responses, limiting factors and tolerance limits, where identified and quantified, and on the existing infrastructure. CCAM will then spatially identify the natural resource element(s) and human infrastructure whose carrying capacities may have been exceeded. In the case of the human infrastructure, the cost estimate for retrofitting and/or new construction to meet the additional population requirements will be provided.

The output provided by the analysis model will enable the user to view the consequences of a future scenario and provide assistance in understanding an element's response to the changes and pressures that different scenarios place on them. Summaries comparing natural resource values to their associated requirements, responses, limiting factors and tolerance limits, where identified and quantified, will be emphasized. GIS maps will be produced that will identify areas in need of restoration. The output will allow the user to view and print information from the CCAM and GIS database in maps, charts, and tables.

Task 1. Build model framework. Scenario inputs; requirements, responses, limiting factors, and tolerance limits, where identified and quantified; and land development activities and population growth cause/effect on natural resources and human infrastructure information will be assembled and made ready for construction of the CCAM. It is understood that the development of this type of carrying capacity analysis model within the Florida Keys has not been completed to date. There are uncertainties among some peer review group participants whether development of this CCAM is

possible. For that reason, a workshop will be held, if necessary, for further definition of the model's framework.

Model Framework Workshop. This workshop will be held approximately one month after study initiation. Participants will include members of the peer review group that reviewed the SOW in March 1998; other identified modeling and natural resource experts; and local, state and federal agency representatives, as appropriate. The purpose of the workshop will be to define the CCAM framework and output (see Task 2). It is anticipated that only one workshop will be required.

Task 2. Develop and format output. Output will be developed that characterizes the Florida Keys ecosystem and human infrastructure after each scenario has been simulated in the CCAM.

Task 3. Construct Model. Based on the model framework and output requirements, the CCAM will be constructed. Adaptive management will be included in the SOW for the model development and construction to ensure that only critical elements remain within the CCAM. For example, if preliminary data collection and integration determine that stormwater is not a critical factor affecting nearshore water quality or human infrastructure requirements in the Florida Keys, then it may be dropped out of the CCAM so that resources can be focused on a more crucial natural resource or human infrastructure limiting element.

Task 4. Testing. Upon completion of design and construction, the CCAM will be tested to ensure ease of use and error free operation.

Task 5. Documentation. The analysis model and the output will be fully documented (twelve 12 printed copies and one diskette in the latest version of Microsoft WORD) in user manuals, help pages, tutorials, technical specification documents, and program coding. All documentation will also be available in soft copy form, through the standardized help interface system, as part of the CCAM.

Task 6. Transitional Training. The transfer of the CCAM to Monroe County, DCA and other appropriate agencies will include hands-on training.

References:

U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources. *An Introduction to Risk and Uncertainty in the Evaluation of Environmental Investments*. IWR Report 96-R-8. Alexandria, Virginia. March 1996.